The provenance of *Sivapithecus africanus*

P. J. Andrews and **T. I. Molleson**

Subdepartment of Anthropology, British Museum (Natural History), Cromwell Road, London SW7 5BD

Synopsis

Controversy over the taxonomic affinities of *Sivapithecus africanus* from Miocene deposits in Kenya has been increased by doubts about its provenance. One specimen is known to be from middle Miocene deposits on Maboko Island, and the only other specimen of 'known' provenance is the type specimen (M 16649), which is reported as coming from Rusinga Island. There is considerable doubt over this, however, so X-ray fluorescence spectrometry (XRF) of the matrix of M 16649 has been attempted to try and establish its site of origin. The XRF spectrum for M 16649 shows great differences from the range of patterns found for the Rusinga Island sites, and it shows the greatest similarity with the spectra from several different levels of the Maboko Island deposits. In some ways, however, the XRF spectrum for M 16649 is unlike any of the samples tested, so while it can be concluded that this specimen probably did not come from Rusinga Island, it is not yet clear where it did come from.

Introduction

Sivapithecus africanus was first described in 1950 on the basis of a maxilla (registration number M 16649) and two isolated teeth (Clark & Leakey 1950, 1951). These specimens differ morphologically from other East African Miocene dryopithecines, although the maxilla was initially assigned (MacInnes 1943) to a species of *Proconsul* Hopwood 1933. Clark & Leakey (1950, 1951), in the first major revision of the East African Miocene Hominoidea, redescribed the specimens and recognized their differences from other specimens of *Proconsul* by assigning them to a new species of the Asian middle to late Miocene genus *Sivapithecus*. This view gained some measure of support when Simons & Pilbeam (1965) synonymized *S. africanus* with a previously-described species of the same genus, calling it *Dryopithecus* (*Sivapithecus*) *sivalensis* (Lydekker, 1879). Two years later, Leakey (1967, 1968), who never accepted Simons & Pilbeam's synthesis, referred *Sivapithecus africanus* to the genus *Kenyapithecus*, which had as its type species *K. wickeri* from Fort Ternan, Kenya (Leakey 1962). Pilbeam (1969) and Andrews (1971, 1973) later synonymized *Kenyapithecus* with *Ramapithecus* and referred all the '*K. africanus*' specimens, including M 16649, to species of *Proconsul* (or as it then was, *Dryopithecus*). The situation still remains, however, that these specimens are very distinctive, with at least two autapomorphic characters and only one synapomorphy with later Miocene species of *Ramapithecus*, *Sivapithecus* and *Dryopithecus*, so that on present evidence there is no justification for retaining them either in *Proconsul* or in *Sivapithecus*. This uncertainty is increased by doubts over the provenance of two of the three known specimens.

One of the isolated teeth attributed to '*Sivapithecus africanus*' is the only specimen of confirmed provenance. This is an upper molar (specimen CMH 26 in Clark & Leakey 1951; KNM-MB 107 in Andrews 1973) and it is said to be from middle Miocene deposits on Maboko Island, Kenya. The other isolated tooth is from an unknown locality in western Kenya (Clark & Leakey 1951), and the third and only other specimen is the type specimen, M 16649, which is said by Clark & Leakey (1951) to have been recovered from early Miocene deposits at R106 on Rusinga Island, Kenya. In the first description of the specimen, however, MacInnes (1943) did not identify the locality: the collection as a whole was made in 1932–35 by L. S. B. Leakey's East African Archaeological Expeditions to Rusinga Island and Songhor, but at least one of the specimens, the mandible of a cercopithecoid primate, is almost certainly not from these early Miocene deposits but from Maboko Island, three to four million years later in time. Because the preservation of M 16649 is unlike that of other specimens known to be from Rusinga Island, and in particular R106, we

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Table 1

Tube anode	current	voltage	crystal	detector	path	window	attenuation
Tungsten	30 MA	60 kV	LiF 200	flow counter	air	1·0–∞	2^2
Chromium	30 MA	60 kV	LiF 200	flow counter	air	1·0–∞	2^2

Table 2

2θ scanning speed	chart speed	full scale deflection	time constant
2°/min. betw. 15° and 126°	25 mm/min.	1000 counts/sec.	0·4 or 1·0 sec.

Notes on Table 3

Zirconium (Zr) $K\alpha_{1,2}$ (22·55°), $K\beta_1$ (20·07°), $K\alpha_{1,2}$ (2nd order 46·04°), $K\alpha_{1,2}$ (4th order 102·91°). It is difficult to assess the presence of zirconium by XRF since at most angles the line is masked by strontium, which is usually the more abundant element. By checking for other lines, e.g. $K\beta_1$ (20·07°), and by comparing the strontium $K\alpha_{1,2}$ (25·15°) line with the zirconium $K\alpha_{1,2}$ (22·55°) plus strontium $K\beta_1$ (22·42°) line, it was possible to deduce the presence or absence of zirconium in the sample. Zirconium was present in 10 of the 14 samples from Rusinga but in only 4 of the 7 samples from Maboko and 1 of 4 samples from Songhor. There was no indication of the presence of zirconium in the *Sivapithecus* sample.

Yttrium (Y) $K\alpha_{1,2}$ (23·80°). Yttrium is clearly present in the *Sivapithecus* matrix and in most of the samples from Maboko and Songhor (6 out of 7 and 3 out of 4 samples respectively). On the whole it is not an important element in the samples from Rusinga although it is clearly present in M 15323 from R106.

Rubidium (Rb) $K\alpha_{1,2}$ (26·62°). Rubidium is a more important constituent of most of the Rusinga samples than it is of the Maboko ones. It was not detected in the *Sivapithecus* matrix.

Lead (Pb) $L\alpha_1$ (33·93°), $L\beta_1$ (28·26°). Lead $L\alpha_1$ and $L\beta_1$ lines were observed in the matrix of *Sivapithecus*. They were most clearly present again in the matrix of M 16632 from Maboko. Small $L\alpha_1$ peaks were seen in the spectra for several other samples from Maboko. Only two or possibly three samples from Rusinga had a very small quantity of lead.

Zinc (Zn) $K\alpha_{1,2}$ (41·80°), $K\alpha_{1,2}$ (2nd order 91·04°). Zinc was present in all the samples, but the lines were particularly strong in the *Sivapithecus* spectrum and in the spectra for M 16632 (Maboko) and M 32949 (Mfwangano).

Copper (Cu) $K\alpha_{1,2}$ (41·80). Copper is not an important constituent of the *Sivapithecus* matrix nor of the samples from Maboko. In every case it was more important in the samples from Rusinga and Songhor. This was clearly further demonstrated in the chromium tube spectra.

Nickel (Ni) $K\alpha_{1,2}$ (48·67). A similar picture was noted for nickel.

Neodymium (Nd) $L\alpha_1$ (72·13°). Neodymium, if correctly identified, is present in the *Sivapithecus* sample and in 4 out of 7 of the Maboko samples but in only 3 out of 14 of the samples from Rusinga. It was not detected in the samples from Songhor.

Vanadium (V) $K\alpha_{1,2}$ (76·94°). The vanadium $K\alpha_{1,2}$ line at 76·94° tends to be difficult to distinguish from the titanium $K\beta_{1,3}$ line at 77·27°, but it is clearly present in the spectrum of the *Sivapithecus* matrix (where the titanium content is low) and of all except one of the samples from Maboko. Vanadium was detected in only one of the Rusinga samples (M 32847).

Titanium (Ti) $K\alpha_{1,2}$ (86·14°). Titanium is a minor constituent in the *Sivapithecus* matrix and in most of the samples from Maboko and Songhor whereas it is an important element in at least half of the samples from Rusinga.

Barium (Ba) $L\alpha_1$ (87·17°). Barium was clearly present in the *Sivapithecus* matrix and in all except one sample from Maboko, but was detected in only a few samples from Rusinga, when it was observed at low levels.

Table 3 XRF readings expressed as a proportion of the tungsten (W) $L\gamma_1$ line $2\theta = 31{\cdot}66°$

Locality	Specimen number	Nb $K\alpha_{1,2}$ 21·40	Zr $K\alpha_{1,2}$ 22·25	Y $K\alpha_{1,2}$ 23·80	Sr $K\alpha_{1,2}$ 25·15	Rb $K\alpha_{1,2}$ 26·62	Pb $L\alpha_1$ 33·93	Zn $K\alpha_{1,2}$ 41·80	Cu $K\alpha_{1,2}$ 45·03	Ni $K\alpha_{1,2}$ 48·67	Cr $K\alpha_{1,2}$ 69·36	Ce $L\beta_1$ 71·06	Nd $L\alpha_1$ 72·13	V $K\alpha_{1,2}$ 76·94	Ti $K\alpha_{1,2}$ 86·14	Ba $L\alpha_1$ 87·17	K $K\beta_{1,3}$ 118·30
(Mylar only)	blank	0	0	0	0	0	0	4·0	10·0	3·0	0	0	0	0	0	0	0
?	*Sivapithecus africanus* M 16649	3·0	nd	6·0	53·0	nd	12·0	45·0	20·0	10·0	4·0	5·0	3·0	pres	23·0	10·0	3·0
Rusinga																	
R1	M 21341	1·6	nd	2·4	56·0	2·6	2·6	24·8	24·8	10·5	2·4	2·4	nd	nd	44·6	nd	4·8
R2	M 32834	4·4	pres	nd	46·6	4·4	nd	27·3	59·0	13·2	6·2	nd	nd	nd	74·8	nd	3·5
R3	M 32447	nd	nd	nd	25·6	nd	nd	10·5	23·5	11·5	2·4	nd	nd	nd	44·9	3·2	0·8
R7	M 25168	nd	nd	nd	62·1	nd	nd	6·8	21·3	11·9	2·6	nd	nd	nd	23·8	nd	0·9
R7	M 32838	2·0	pres	1·0	31·0	nd	nd	11·0	26·0	9·0	2·0	2·0	2·0	nd	40·0	1·0	nd
R74	M 34115	2·3	pres	nd	18·2	2·3	1·5	11·4	19·8	10·6	3·0	nd	nd	nd	58·5	5·3	0·8
R105	M 18920	2·2	pres	nd	26·2	3·3	nd	19·8	25·2	12·1	5·5	2·2	1·1	nd	88·0	nd	5·5
R105	—	1·6	pres	2·4	40·3	3·2	nd	23·7	28·4	10·3	2·4	2·4	nd	nd	71·1	nd	4·0
R106	M 15320	1·5	pres	0·8	39·5	2·3	nd	16·7	23·6	7·6	2·3	nd	nd	nd	50·2	nd	3·0
R106	M 15323	1·8	pres	5·3	74·8	1·8	nd	16·7	30·8	7·9	5·3	7·0	4·4	nd	46·6	nd	2·6
R106	M 32363	2·3	pres	nd	32·4	2·3	nd	21·1	27·5	16·2	4·9	nd	nd	nd	60·8	nd	2·4
R106	M 32847	1·7	pres	nd	29·8	1·7	nd	11·1	26·4	10·2	3·4	nd	nd	nd	57·8	1·7	0·9
R106	—	nd	nd	1·1	75·9	1·1	nd	14·1	25·2	11·1	4·4	6·6	nd	nd	38·5	nd	2·2
R107	M 25270	3·1	pres	1·6	26·8	2·4	?	24·5	33·2	10·3	8·7	1·6	nd	nd	71·1	nd	2·4
Maboko																	
	M 15310	3·4	pres	2·6	25·5	?	nd	18·7	16·2	9·4	8·5	1·7	nd	nd	68·0	4·3	0·85
	M 15438	2·4	nd	3·2	57·7	0·8	1·6	12·6	11·9	5·5	2·4	nd	1·6	pres	34·0	3·2	2·4
primate level	M 16331	2·3	pres	2·4	64·8	0·8	1·6	15·4	20·3	7·3	3·2	nd	1·6	pres	45·5	16·2	2·4
primate level	M 16332	2·9	pres	3·8	73·0	nd	4·8	39·4	19·2	5·8	1·9	3·8	2·9	pres	17·3	3·8	1·0
	M 30085	4·0	nd	2·0	45·0	2·0	nd	13·0	nd	6·0	nd	nd	nd	pres	11·0	nd	1·0
	M 32748	2·8	nd	nd	54·3	nd	1·8	17·5	21·2	7·2	3·7	1·0	0·9	pres	78·2	16·6	?
		3·3	pres	1·6	38·9	1·6	3·2	16·2	12·2	7·3	4·1	nd	nd	pres	47·8	4·1	nd
Songhor																	
	M 32730	0·8	pres	1·6	34·0	nd	2·4	25·9	17·0	6·5	3·2	2·4	nd	pres	21·1	4·9	?
	M 34117	nd	nd	nd	11·4	1·8	nd	15·8	30·8	11·4	7·9	nd	nd	nd	66·0	2·6	?
Bed 9	Sgr 1	5·8	nd	1·2	27·8	?	nd	32·5	31·3	16·2	8·1	?	nd	nd	30·2	nd	nd
Bed 5	Sgr 2	3·7	pres	1·5	33·6	2·2	1·5	21·2	20·4	13·1	7·3	2·9	nd	pres	28·5	nd	1·5
Other sites																	
Arongo Uyoma	—	3·2	nd	1·6	47·0	2·4	nd	8·9	19·4	8·9	1·6	0·8	nd	pres	34·0	1·6	0·8
Mfwangano	M 32949	9·3	nd	1·7	63·8	2·6	2·6	41·7	16·2	6·8	1·7	3·4	2·6	pres	17·0	2·6	0·9
Ombo	M 29427	nd	nd	nd	67·2	1·7	3·4	17·0	25·5	17·0	3·4	0·9	nd	pres	23·8	1·7	nd

have examined the matrix from the specimen by qualitative X-ray fluorescence analysis and compared it with matrix samples from a number of Miocene localities in Kenya to try and determine which locality it may be from.

Methods and results

Matrices taken from 28 East African specimens in the collection of the British Museum (Natural History) were sampled. These represented six East African Miocene sites. We concentrated on material from Rusinga (14 samples), Songhor (4 samples) and Maboko (7 samples) and took single samples from several other sites.

X-ray fluorescence spectra were recorded using a Philips PW 1140 generator, PW 1540 goniometer and PM 800 flat bed recorder. Samples of the finely powdered matrix of 150–160 mg were weighed out and distributed in an even layer over a Mylar film in a standard Philips sample holder before being placed in the X-ray beam. Instrument and running parameters are listed in Tables 1 and 2. A blank Mylar film was run to determine impurities in the tube.

Eight of the samples, including the matrix of M 16649, were run again in the same conditions but using larger samples of powder (500–700 mg) and a chromium tube in place of the tungsten tube. This allowed a check to be made for those elements (tungsten, nickel, vanadium) that are masked by the lines of the tungsten X-ray tube. The spectra derived from the different tubes, however, cannot be compared directly since some elements are energized more readily by one tube than by the other.

A rough estimate of the relative abundance of the different elements present was made by measuring the heights of the lines presented by each sample. These heights were all normalized to the tungsten $L\gamma_1$ line at $2\theta = 31{\cdot}66°$. The figures obtained, while not calibrated for quantitative determination, were tabulated (Table 3) so that comparisons can be made of the different samples with each other and with the sample from M 16649. The plot for M 16649 was read last to avoid bias in interpretation.

Conclusions

Rusinga island. In general the matrix samples from Rusinga Island have relatively high concentrations of copper, iron and titanium and contain appreciable amounts of zirconium. Zinc and manganese are not important constituents. Yttrium and barium are often not present and it is unusual for the material to contain lead or vanadium. Rubidium is usually present.

Maboko. The samples from Maboko contain relatively high levels of manganese and vanadium. Zinc, copper, iron, titanium and potassium are less important than they are in samples from Rusinga. Yttrium, lead and barium are usually present whereas rubidium is only present in very minor quantities.

Songhor. The four samples from Songhor have relatively low concentrations of zirconium, lead, zinc, iron or vanadium. Strontium, titanium and calcium can also be rather low. Neodymium was not detected in any of the four samples nor was potassium clearly present in three of them.

Sivapithecus africanus, M 16649. The matrix from this specimen contained relatively high levels of zinc, manganese, vanadium and calcium, but comparatively low levels of copper, iron and potassium. There were clear peaks for yttrium, lead, neodymium and barium. Rubidium was not detected and zirconium is probably not present. The presence of yttrium, barium, neodymium, lead and vanadium and the absence of rubidium make up a pattern that is very different from the Rusinga pattern. In many respects the XRF spectrum of M 16649 is more like those from the Maboko Island samples, but between these also there are differences, for instance in the presence of rubidium and lower levels of lead in the Maboko samples. It is concluded, therefore, that there are very strong reasons for doubting the reports that M 16649 is from R106 on Rusinga Island and that it may be from Maboko Island, but that the data are insufficiently conclusive to show definitely which site it may be from.

The results of this analysis would seem to indicate the value of carrying out further work along these lines. In the first instance, samples of controlled provenance should be collected rather than relying on matrix samples from specimens collected many years ago. A wider variety of localities could be sampled and much larger samples would be available, and in addition to XRF their mineralogical and elemental characteristics could be determined.

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Postscript

Since writing this report, Dr Martin Pickford has found in the collections of the British Museum (Natural History) the broken fragment of a left P_3 from Maboko Island. It is clearly labelled as coming from Maboko Island and has been registered M 36370. It has the same combination of grey enamel and white bone seen on M 16649 and, although no matrix is preserved so that it cannot be compared directly with that specimen, the colour similarity, which is unique to these two specimens from the Miocene of East Africa, must be considered additional indication that they both originated from Maboko Island. The specimen itself has a robust crown with a broad flattened anterior wear facet. Enamel thickness varies up to 1·1 mm at the break on the buccal face, and although the tip of the crown is broken it appears to have been low-crowned. M 36370 is thus consistent in size and morphology with the other specimens of '*Sivapithecus africanus*'.

References

Andrews, P. J. 1971. *Ramapithecus wickeri* mandible from Fort Ternan, Kenya. *Nature, Lond.* **231** : 192–194.

—— 1973. *Miocene primates* (*Pongidae, Hylobatidae*) *of East Africa*. xix + 511 + x pp., 82 figs. Ph.D. thesis, University of Cambridge.

Clark, W. E. Le Gros & Leakey, L. S. B. 1950. Diagnoses of East African Miocene Hominoidea. *Q. Jl geol. Soc. Lond.* **105** : 260–262.

—— —— 1951. The Miocene Hominoidea of East Africa. *Fossil Mammals Afr.*, London, **1**. v + 117 pp., 28 figs, 9 pls.

Hopwood, A. T. 1933. Miocene primates from Kenya. *Zool. J. Linn. Soc.*, London, **38** : 437–464, pl. 6.

Leakey, L. S. B. 1962. A new Lower Pliocene fossil primate from Kenya. *Ann. Mag. nat. Hist.*, London, (13) **4** : 689–696, pl. 18.

—— 1967. An early Miocene member of Hominidae. *Nature, Lond.* **213** : 155–163.

—— 1968. Lower dentition of *Kenyapithecus africanus*. *Nature, Lond.* **217** : 827–830.

Lydekker, R. 1879. Further Notices of Siwalik Mammalia. *Rec. geol. Surv. India*, Calcutta, **12** (1) : 33–52, plate.

MacInnes, D. G. 1943. Notes on the East African Miocene primates. *Jl E. Africa nat. Hist. Soc.*, Nairobi, **17** : 141–181.

Pilbeam, D. R. 1969. Tertiary Pongidae of East Africa: evolutionary relationships and taxonomy. *Bull. Peabody Mus. nat. Hist.*, New Haven, **31** : 1–185, 31 figs.

Simons, E. L. & Pilbeam, D. R. 1965. Preliminary revision of the Dryopithecinae (Pongidae, Anthropoidea). *Folia primatol.*, Basel, **3** : 81–52.